



**Convention on  
Biological Diversity**

Distr.  
GENERAL

UNEP/CBD/SBSTTA/18/6  
16 June 2014\*\*

ORIGINAL: ENGLISH

SUBSIDIARY BODY ON SCIENTIFIC,  
TECHNICAL AND TECHNOLOGICAL ADVICE  
Eighteenth meeting  
Montreal, 23-28 June 2014  
Item 4.4 of the provisional agenda\*

**SYSTEMATIC REVIEW ON THE IMPACTS OF OCEAN ACIDIFICATION AND  
PROPOSAL TO UPDATE THE SPECIFIC WORKPLAN ON CORAL BLEACHING**

*Note by the Executive Secretary*

**I. INTRODUCTION**

1. Increasing research on the impacts of ocean acidification on marine biodiversity has improved understanding of its impacts on and the potential wide-reaching implications for marine ecosystems. It is important to continue to build the knowledge base on the impacts of ocean acidification in order to inform Parties, other Governments and relevant organizations in applying relevant policy measures. Further research is needed to reduce the uncertainties related to future impacts and improve the development and application of appropriate policy responses.

2. There has been considerable progress made in the implementation of the specific workplan on coral bleaching in terms of enhancing reef resilience, coral bleaching response planning, and the availability of scientific information on coral ecosystems. However, in light of the growing body of research on coral bleaching and experience gained thus far, it is important to update the workplan, through an addendum to the workplan, to address compounding effects of multiple stressors such as ocean acidification, sea level rise and increasing natural tropical storms, among other stressors.

3. Pursuant to decision XI/18 A, the Executive Secretary has carried out a number of activities addressing the adverse impacts of human activities on marine and coastal biodiversity, in particular ocean acidification and coral bleaching, including:

(a) Preparation of an updated synthesis of the impacts of ocean acidification on marine biodiversity; and

(b) Compilation and synthesis of proposals to update the specific workplan on coral bleaching through an addendum to the workplan.

\*\* Reposted with a technical change to paragraph 8.1 (d) in annex II.

\* UNEP/CBD/SBSTTA/18/1.

4. These activities support the achievement of, in particular, Aichi Biodiversity Target 10 of the Strategic Plan, among others: *“By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.”*

## II. SYSTEMATIC REVIEW ON THE IMPACTS OF OCEAN ACIDIFICATION

5. Pursuant to paragraph 23 of decision XI/18 A, the Executive Secretary prepared a systematic review document on the impacts of ocean acidification on biodiversity and ecosystem functions, which provides a targeted synthesis of the biodiversity implications of ocean acidification for marine and coastal systems, including information on the less-reported paleo-oceanographic research, building upon the synthesis provided in CBD Technical Series No. 46 (available at <http://www.cbd.int/doc/publications/cbd-ts-46-en.pdf>).

6. A draft of the systematic review document was circulated for peer review by Parties, other Governments and relevant organizations, in particular the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, relevant scientific groups, other relevant organizations, and indigenous and local communities, through notification 2014-004 (Ref. no. SCBD/SAM/DC/JL/JM/83041), issued on 10 January 2014.

7. The comments and suggestions received through peer review were integrated into the revised draft of the systematic review document, which is provided as UNEP/CBD/SBSTTA/18/INF/6. The key messages of the systematic review document are provided in annex I below.

## III. PROPOSAL TO UPDATE THE SPECIFIC WORKPLAN ON CORAL BLEACHING

8. Pursuant to paragraph 13 of decision XI/18 A, the Executive Secretary compiled and synthesized proposals to update the specific workplan on coral bleaching through an addendum to the workplan.

9. In decision XI/18 A, the Conference of the Parties expressed its deep concern that climate change will increase the severity and incidence of coral bleaching and ocean acidification in the twenty-first century (paragraph 7). The Conference of the Parties also took note of the urgent need to update the specific workplan on coral bleaching (appendix 1 of annex I to decision VII/5), taking into consideration other global impacts on coral caused by climate change, most notably, projected impacts of ocean acidification, but also the effects of tropical storms and rising sea levels, and recognized that the projected impacts of ocean acidification need to be integrated into management frameworks alongside interaction with local stressors (paragraph 9).

10. In paragraph 13 of decision XI/18 A, the Conference of the Parties requested the Executive Secretary to collaborate with Parties, other Governments, relevant organizations, and indigenous and local communities to develop proposals to update the specific workplan on coral bleaching through an addendum to the workplan that addresses the needs set out in paragraph 11, as follows:

- (a) Understand the vulnerability of corals to multiple stressors;
- (b) Plan proactively for climate risks and associated secondary effects, applying ecosystem-based adaptation measures;
- (c) Manage coral reefs as socioecological systems undergoing change due in many cases to climate change; and
- (d) Formulate adaptation strategies that aim to enhance the resilience of ecosystems to enable the continued provision of goods and services.

11. Parties, other Governments, relevant organizations, and indigenous and local communities were invited to submit information that may contribute to the development of proposals to update the specific workplan on coral bleaching, including relevant scientific and technical information, case studies, tools and guidance, and relevant management plans at subnational, national or regional levels as well as

specific suggestions for inclusion in the development of proposals to update the specific workplan on coral bleaching through an addendum to the workplan.

12. The Secretariat received submissions from the Governments of Colombia, Cuba, India, Israel, Japan, Mexico, Norway, the United Kingdom of Great Britain and Northern Ireland, and the United States of America, the European Commission, the United Nations Environment Programme (UNEP), the Great Barrier Reef Marine Park Authority, the International Coral Reef Initiative (ICRI) Secretariat, Initiative Française pour les Récifs Coralliens (IFRECOR), and the World Wildlife Fund.

13. The Secretariat commissioned the preparation of a background document on achieving Aichi Biodiversity Target 10 for coral reefs and closely associated ecosystems, which characterizes the vulnerability of shallow coral reefs in low latitudes to climate change, ocean acidification and other major stressors, highlights implications of this vulnerability for related ecosystems and reef-dependent communities, and discusses various approaches to managing multiple stressors and improving the resilience of coral reefs. This background document will be made available to the Subsidiary Body as an information note.

14. While the existing specific workplan on coral bleaching focuses on sea surface temperature as the main global stressor, it has become apparent since the development of the workplan that ocean acidification is also a major threat to coral reef ecosystems. As such, it is considered appropriate to broaden the scope of the updated workplan to address the full range of anthropogenic pressures, in line with Aichi Biodiversity Target 10.

15. Taking into account the submissions from Parties, other Governments and relevant organizations, the updated synthesis of the impacts of ocean acidification on marine biodiversity, the background document on coral reefs, and existing initiatives and programmes to address the threats to coral reefs, the Secretariat has developed a proposal on **priority actions to achieve Aichi Biodiversity Target 10 for coral reefs and closely associated ecosystems**, contained in annex II below, as a proposed addendum to the existing workplan on coral bleaching.

#### IV. SUGGESTED RECOMMENDATION

16. The Subsidiary Body on Scientific, Technical and Technological Advice may wish to recommend that the Conference of the Parties, at its twelfth meeting, adopt a decision along the following lines:

*The Conference of the Parties,*

##### ***Impacts of ocean acidification on marine and coastal biodiversity***

*Recalling* paragraphs 63 to 67 of decision X/29 and paragraph 23 of decision XI/18 A,

1. *Expresses its gratitude* to the Government of the United Kingdom of Great Britain and Northern Ireland for supporting the scientific compilation, coordination and synthesis work for, and international experts for contributing to, the preparation of a systematic review document on the impacts of ocean acidification on biodiversity and ecosystem functions (UNEP/CBD/SBSTTA/18/INF/6), which provides a targeted synthesis of the biodiversity implications of ocean acidification for marine and coastal systems, including information on the less-reported paleo-oceanographic research, and *welcomes* this updated synthesis of the impacts of ocean acidification on marine biodiversity (UNEP/CBD/SBSTTA/18/INF/6);

2. *Takes note* that in waters where pH is already naturally comparatively low (e.g., in high latitudes, coastal upwelling regions and on the shelf slope) widespread undersaturation of both aragonite and calcite is expected to develop during this century, and that benthic and planktonic molluscs are among the groups likely to be affected, as well as cold-water corals and the structural integrity of their habitats;

3. *Urges* Parties, other Governments, the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, relevant scientific groups, and other relevant organizations, to further enhance their international collaboration to improve ocean acidification monitoring, closely linked to other global ocean observing systems, noting that a well-integrated global monitoring network for ocean acidification is crucial to improve understanding of current variability and to develop models that provide projections of future conditions;

4. *Requests* the Executive Secretary to forward the updated synthesis of the impacts of ocean acidification on marine biodiversity (UNEP/CBD/SBSTTA/18/INF/6) to Parties, other Governments and relevant organizations and to transmit it to the Secretariat of the United Nations Framework Convention on Climate Change; and to continue to collaborate with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, relevant scientific groups, other relevant organizations, and indigenous and local communities to raise awareness on the key findings from the updated synthesis and facilitate incorporating these findings into relevant national strategies and action plans concerning conservation and sustainable use of marine and coastal biodiversity as well as developing relevant research and monitoring programmes at global, regional and national levels;

***Priority actions to achieve Aichi Biodiversity Target 10 for coral reefs and closely associated ecosystems***

5. *Recalling* paragraph 9 of decision XI/18 A, *endorses* the priority actions to achieve Aichi Biodiversity Target 10 for coral reefs and closely associated ecosystems,<sup>1</sup> as an addendum to the programme of work on marine and coastal biodiversity, in order to update the specific workplan on coral bleaching<sup>2</sup> of the programme of work (annex II to UNEP/CBD/SBSTTA/18/4), and *urges* Parties, with the support of relevant organizations, to implement the activities contained therein, where applicable and in accordance with national capacity and circumstances, for enhanced implementation toward achieving Aichi Biodiversity Target 10;

6. *Recognizing* that increased sea temperature also increases risks to coral reefs from pathogens and that there are additional interactions, often synergistic, among all these stressors, *urges* Parties, other Governments and relevant organizations to consolidate and further strengthen current efforts at local, national, regional and global levels to manage coral reefs as socioecological systems undergoing change due to the interactive effects of multiple stressors, including both global stressors (e.g., rising sea temperature, the effects of tropical storms and rising sea levels, as well as ocean acidification,) and local stressors (e.g., overfishing, destructive fishing practices, land-based and sea-based pollution, coastal development, tourism and recreational use, etc.), focusing on actions that address, in particular:

(a) Reducing the impacts of multiple stressors, in particular by addressing those stressors that are more tractable at the regional, national and local levels;

(b) Enhancing the resilience of coral reefs and closely associated ecosystems through ecosystem-based adaptation to enable the continued provisioning of goods and services;

(c) Maintaining sustainable livelihoods and food security in reef-dependent coastal communities and provide for viable alternative livelihoods, where appropriate;

(d) Increasing the capability of local and national managers to forecast and plan proactively for climate risks and associated secondary effects, applying ecosystem-based adaptation measures; and

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<sup>1</sup> On the basis of annex II to UNEP/CBD/SBSTTA/18/6.

<sup>2</sup> Appendix 1 of annex I to decision VII/5.

(e) Enhancing international and regional cooperation in support of national implementation of priority actions, building upon existing international and regional initiatives and creating synergies with various relevant work within the Convention.

7. *Recalling* paragraph 14 of decision XI/18 A, further *requests* the Executive Secretary, in collaboration with Parties, other Governments and relevant organizations, to facilitate the implementation of the priority actions to achieve Aichi Biodiversity Target 10 for coral reefs and closely associated ecosystems through organizing capacity-building workshops and developing information-sharing mechanisms on experiences and lessons learned from various implementation activities;

8. *Noting* that deep-water corals are also vulnerable to the effects of ocean acidification, but are impacted by additional stressors that are different from those affecting warm-water coral reefs, *requests* the Executive Secretary to prepare, in collaboration with Parties, other Governments and relevant organizations, a draft specific workplan on cold-water corals, building upon the elements of a workplan on physical degradation and destruction of coral reefs, including cold-water corals (appendix 2 of annex I to decision VII/5) and in close linkage with the relevant work under the Convention, such as the description of areas meeting the scientific criteria for ecologically or biologically significant marine areas, and relevant competent organizations, such as FAO's work on vulnerable marine ecosystems (VMEs), and submit the draft specific workplan on cold-water corals for consideration to the future meeting of the Subsidiary Body prior to the thirteenth meeting of the Conference of the Parties to the Convention.

*Annex I***EXECUTIVE SUMMARY OF THE UPDATED SYNTHESIS OF THE IMPACTS OF OCEAN ACIDIFICATION ON MARINE BIODIVERSITY**

1. **Ocean acidification has increased by about 30% since pre-industrial times.** In the past 200 years, it is estimated that the ocean has absorbed nearly a third of the carbon dioxide released by human activity, increasing ocean acidity (hydrogen ion concentration) by a similar proportion in the upper ocean. It is now nearly inevitable that within 50-100 years, continued anthropogenic carbon dioxide emissions will further increase ocean acidity to levels that will have widespread impacts, mostly deleterious, on marine organisms and ecosystems, and the goods and services they provide. Marine calcifying organisms seem particularly at risk, since additional energy will be required to form shells and skeletons, and in many ocean areas, unprotected shells and skeletons will dissolve.

*Current awareness*

2. **International awareness of ocean acidification and its potential consequences is increasing.** Many programmes and projects are now investigating the impacts of ocean acidification on marine biodiversity and its wider implications, with strong international linkages. The United Nations General Assembly has urged States to study ocean acidification, minimize its impacts and tackle its causes.<sup>3</sup> Many United Nations bodies are giving attention to these issues.

*Global status and future trends of ocean acidification*

3. **Substantial natural temporal and spatial variability exists in seawater pH.** The acidity of seawater varies naturally on a diurnal and seasonal basis, on a local and regional scale, and as a function of water depth. Coastal ecosystems and habitats experience greater variability than those in the open ocean, due to both physical and biological processes.

4. **Substantial natural biological variability exists in organisms' responses to pH changes.** Metadata analyses, combining results from many experimental studies, show that there are different, but consistent, patterns in the response of different taxonomic groups to simulated future ocean acidification. There can also be variability in responses within species, depending on interactions with other factors.

5. **Surface waters in polar seas and upwelling regions are increasingly at risk of becoming unsaturated with respect to calcium carbonate, dissolving unprotected shells and skeletons.** In waters where pH is already naturally low (in high latitudes, coastal upwelling regions and on the shelf slope) widespread undersaturation of both aragonite and calcite is expected to develop during this century. Benthic and planktonic molluscs are amongst the groups likely to be affected, as well as cold-water corals and the structural integrity of their habitats.

6. **International collaboration is underway to improve ocean acidification monitoring, closely linked to other global ocean observing systems.** A well-integrated global monitoring network for ocean acidification is crucial to improve understanding of current variability and to develop models that provide projections of future conditions. Emerging technologies and sensor development increase the efficiency of this evolving network.

*What the past can tell us: palaeo-oceanographic research*

7. **During natural ocean acidification events which occurred in the geological past, many marine calcifying organisms became extinct.** High atmospheric carbon dioxide has caused natural ocean acidification in the past, linked to "coral reef crises". During the Palaeo-Eocene Thermal Maximum (PETM, around 56 million year ago), more limited species extinctions occurred; however, the changes that occurred then were much slower than those happening today.

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<sup>3</sup> A/RES/65/37, A/RES/68/70.

8. **Recovery from a major decrease in ocean pH takes many thousands of years.** The palaeo-record shows that recovery from ocean acidification can be extremely slow; for example, around 100,000 years following the PETM.

*Impact of ocean acidification on biodiversity and ecosystem function*

*Physiological responses*

9. **Ocean acidification has implications for acid-base regulation and metabolism for many marine organisms.** When external hydrogen ion levels substantially increase, extra energy may be required maintain the internal acid-base balance. This can lead to reduced protein synthesis and reduction in fitness. Such effects are greatest for sedentary animals, but can be mitigated if food supply is abundant.

10. **Impacts of ocean acidification upon the success of invertebrate fertilization are highly variable, indicating the potential for genetic adaptation.** Experimental studies on the effect of ocean acidification on fertilization show that some species are highly sensitive, whilst others are tolerant. Intra-specific variability indicates the scope for a multigenerational, evolutionary response.

11. **Ocean acidification is generally detrimental for calcifying larvae.** Early life stages of a number of organisms seem to be particularly at risk from ocean acidification, with impacts including decreased larval size, reduced morphology complexity, and decreased calcification.

12. **Ocean acidification can alter sensory systems and behaviour in fish and some invertebrates.** Impacts include the loss of ability to discriminate between important chemical cues. Individuals may become more active, liable to exhibit bolder and more risky behaviour.

*Benthic communities*

13. **Many benthic invertebrates have lower growth rates and survival under projected future acidification.** For corals, molluscs and echinoderms, many studies show reduction in growth and reduced survival with ocean acidification. However, these responses are variable, and some species can live at low pH conditions.

14. **Many seaweed (macroalgae) and seagrass species can tolerate, or may benefit from, future ocean acidification.** Non-calcifying photosynthetic species may benefit from future ocean acidification; they are frequently abundant near natural CO<sub>2</sub> seeps. Calcifying macroalgae are, however, negatively impacted. High densities of seagrass and fleshy macroalgae can significantly alter the local carbonate chemistry, with potential benefit for neighbouring ecosystems.

*Pelagic communities*

15. **Many, and possibly most, phytoplankton could benefit from future ocean acidification.** Non-calcifying phytoplankton (e.g., diatoms) can show increased photosynthesis and growth under high CO<sub>2</sub> conditions. The response of calcifying phytoplankton (e.g., coccolithophores) is more variable, both between and within species. Mesocosm experiments provide insights into the community shifts that might arise through competitive interactions, as well as the balance between increased photosynthesis and decreased calcification. The response of bacterio-plankton to ocean acidification has not been well studied, but altered decomposition rates would have implications for nutrient cycling.

16. **Planktonic foraminifera and pteropods seem likely to experience decreased calcification or dissolution under projected future conditions.** The shells of both of these groups are liable to experience dissolution if calcium carbonate saturation drops below 1. Decreases in shell thickness and size of planktonic foraminifera may also decrease the efficiency of future carbon transport between the sea surface and the ocean interior.

*Impact on biogeochemistry*

17. **Ocean acidification could alter many other aspects of ocean biogeochemistry, with feedbacks to climatic processes.** High CO<sub>2</sub> may alter net primary productivity, trace gas emissions,

nitrogen-carbon ratios in food webs and exported particulate matter, and iron bioavailability. The scale and importance of these effects are not yet well understood

#### *Impact on ecosystem services and livelihoods*

18. **Impacts of ocean acidification upon ecosystem services may already be underway.** Ocean acidification is apparently already impacting aquaculture in the Pacific Northwest, where upwelling water may be unsaturated with calcium carbonate. High mortalities in oyster hatcheries can, however, be mitigated by monitoring and management measures. Risks to tropical coral reefs are also of great concern, since the livelihoods of around 400 million people depend upon such habitats. Research on the socioeconomic impacts of ocean acidification has only recently started, and is growing rapidly.

#### *Resolving uncertainties*

19. **Existing variability in organism response to ocean acidification needs to be investigated further, to assess the potential for evolutionary adaptation.** Multigenerational studies with calcifying and non-calcifying algal cultures show that adaptation to high CO<sub>2</sub> is possible for some species. Such studies are more difficult for long-lived organisms, and variability in adaptive capacity is likely. Even with adaptation, community composition and ecosystem function are still likely to change.

20. **Research on ocean acidification increasingly needs to involve other stressors, as will occur under field conditions in the future.** Acidification may interact with many other changes in the marine environment, local and global; these “multiple stressors” include including temperature, nutrients, and oxygen. *In situ* experiments on whole communities (using natural CO<sub>2</sub> vents or CO<sub>2</sub> enrichment mesocosms) provide a good opportunity to investigate impacts of multiple stressors on communities, to increase our understanding of future impacts.

#### *Synthesis*

21. Ocean acidification is currently occurring at a rate around 10 times faster than in the geological record, subjecting marine organisms to an additional, and worsening, environmental stress. Experimental studies show that not all organisms respond in the same way to simulated future conditions: some are negatively impacted, some positively affected, and others apparently unaffected. Furthermore, responses to ocean acidification can interact with other stressors, and vary over time, with some potential for genetic adaptation. These complex and variable experimental results make it extremely challenging to assess how future ocean acidification will affect natural marine communities, food-webs and ecosystems, and the goods and services they provide. Nevertheless, substantive environmental perturbations, increased extinction risk for particularly vulnerable species, and significant socioeconomic consequences all seem highly likely. Further research to reduce the uncertainties relating to future impacts is needed on, *inter alia*: greater use of natural high-CO<sub>2</sub> analogues, the geological record and well-integrated observations, together with large-scale, long-term and multifactorial experimental studies.



*Annex II*

**PRIORITY ACTIONS TO ACHIEVE AICHI BIODIVERSITY TARGET 10 FOR CORAL REEFS AND CLOSELY ASSOCIATED ECOSYSTEMS<sup>4</sup>**

1. Pursuant to paragraph 13 of decision XI/18 A, this proposal on the following action items was prepared to update the specific workplan on coral bleaching (appendix 1 of annex I to decision VII/5) through an addendum to the workplan, taking into account the submissions<sup>5</sup> made by Parties, other Governments and relevant organizations in response to notification 2013-108 (Ref No. SCBD/SAM/DC/JL/JG/82124, issued on 26 November 2013).
2. As such, it builds on the existing specific workplan (appendix 1 of annex I to decision VII/5) and is in line with operational objective 2.3 of the elaborated programme of work on marine and coastal biological diversity (annex I to decision VII/5) as well as the elements of a workplan on physical degradation and destruction of coral reefs, including cold-water corals (appendix 2 of annex I to decision VII/5).
3. It will contribute to the achievement of Aichi Biodiversity Target 10: *By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.* It will also facilitate achieving Aichi Biodiversity Targets 6 and 11.
4. This proposal aims to address the urgent need to consolidate and further strengthen current efforts at local, national, regional and global levels to manage coral reefs as socioecological systems undergoing change due to the interactive effects of multiple stressors, including both global stressors (e.g., rising sea temperature, the effects of tropical storms and rising sea levels, as well as ocean acidification,) and local stressors (e.g., overfishing, destructive fishing practices, land-based and sea-based pollution, coastal development, tourism and recreational use, etc). The proposal recognizes that increased sea temperature also increases risks to coral reefs from pathogens and that there are additional interactions, often synergistic, among all these stressors.
5. In particular, the proposal focuses on actions that will help:
  - (a) **Reduce the impacts of multiple stressors, in particular by addressing those stressors that are more tractable at the regional, national and local levels;**
  - (b) **Enhance the resilience of coral reefs and closely associated ecosystems through ecosystem-based adaptation to enable the continued provisioning of goods and services;**
  - (c) **Maintain sustainable livelihoods and food security in reef-dependent coastal communities and provide for viable alternative livelihoods, where appropriate;**
  - (d) **Increase the capability of local and national managers to forecast and plan proactively for climate risks and associated secondary effects, applying ecosystem-based adaptation measures; and**
  - (e) **Enhance international and regional cooperation in support of national implementation of priority actions,** building upon existing international and regional initiatives and creating synergies with various relevant work within the Convention.

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<sup>4</sup> Draft addendum to update the specific workplan on coral bleaching in the programme of work on marine and coastal biodiversity (appendix 1 of annex I to decision VII/5).

<sup>5</sup> Compilation of submissions is provided in the background document (UNEP/CBD/SBSTTA/18/INF/7).

6. To this end, Parties should develop **national coral reef action strategies**, or equivalent policies, strategies, plans or programmes, consolidating existing national initiatives, as platforms to mobilize inter-agency and cross-sectoral partnerships, as well as close coordination among national and subnational governments and local communities. National strategies should be complemented by regional strategies to address common stressors. National and regional strategies could include elements discussed in this proposal.

7. Recalling paragraph 4 of decision XI/20, Parties are also urged to advocate and contribute to effective carbon dioxide emission reductions, by reducing anthropogenic emissions by sources and by increasing removals by sinks of greenhouse gases under the United Nations Framework Convention on Climate Change, noting also the relevance of the Convention on Biological Diversity and other instruments.<sup>6</sup>

*Parties are encouraged to undertake the following actions:*

8. Strengthen **existing sectoral and cross-sectoral management** to address local stressors, such as overfishing, destructive fishing practices, land- and sea-based pollution, coastal development, tourism and recreational use:

8.1. **Sustainably manage fisheries** for coral reefs and closely associated ecosystems

- a. Conduct comprehensive national assessments, including retrospective analyses, of fisheries, including commercial fisheries as well as small-scale fisheries, to determine the level of unsustainable fishing practices;
- b. Promote community-based measures to manage fisheries sustainably;
- c. Introduce new, or strengthen existing, national regulations and management measures, including the application of the ecosystem approach to fisheries (EAF), to address unsustainable fishing practices, including overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices, and ensure effective enforcement, using relevant guidelines of the Food and Agriculture Organization of the United Nations;<sup>7</sup>
- d. Identify and implement gear-based management measures for multispecies reef fisheries to reduce unsustainable fishing practices;
- e. Sustainably manage populations of key reef fish and invertebrate species targeted by export-driven fisheries or by the aquarium and curio trades, through measures including the setting of targets, identifying indicators for sustainable fishery operations, and establishing monitoring programmes to track fishery condition and management outcomes;
- f. Prioritize the recovery and sustainable management of herbivorous reef fish populations, in particular species with key ecological functions.

8.2. **Manage land-based and sea-based sources of pollution**

- a. Identify all sources of significant land-based and sea-based pollutants affecting coral reefs and set up comprehensive national/local water quality monitoring programmes;
- b. Implement comprehensive watershed and coastal water quality management plans that reduce all major types of pollution, especially those causing eutrophication, sublethal effects on corals, lower seawater pH or other negative impacts;

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<sup>6</sup> <http://www.cbd.int/doc/decisions/cop-11/cop-11-dec-20-en.pdf>.

<sup>7</sup> FAO Code of Conduct for Responsible Fisheries, FAO guidance and tools on Ecosystem Approach to Fisheries (EAF).

- c. Implement watershed management policies that address reforestation; erosion control; runoff reduction; sustainable agriculture and mining; reduction of pesticides, herbicides, fertilizer and other agrochemical use, and wastewater management and treatment;
  - d. Prioritize the reduction of nutrient and sediment pollution from watersheds, and the management of pollution “hotspots” (areas that produce the highest pollution loads);
  - e. Implement best practice standards for mariculture, tourism or recreational operations conducted in coral reefs or adjacent environments;
- 8.3. **Increase spatial coverage and effectiveness of marine and coastal protected and managed areas** in coral reefs and closely associated ecosystems
- a. Improve the management of existing areas protecting coral reefs and related ecosystems, including mangrove and seagrass habitats, so that they meet their management and broader ecological objectives;
  - b. Prioritize the full protection of existing healthy, resilient and resistant coral reefs through the development and effective management of marine and coastal protected areas or as part of locally managed marine areas (LMMAs);
  - c. Integrate ecological and social resilience factors of coral reefs and closely associated ecosystems into design and management of marine protected area (MPA) networks;
  - d. Prioritize the enhancement of conservation and management measures for coral reefs and closely associated ecosystems in areas described to meet the scientific criteria for ecologically or biologically significant marine areas (EBSAs);<sup>8</sup>
  - e. Improve the design of coral reef related MPA networks to improve the ability of coral reefs to cope with future climate and ocean change effects;
  - f. Encourage and support community-based marine managed areas, in line with national policies for marine and coastal management, national or legislative frameworks or other measures;
- 8.4. **Manage coastal development** to ensure that the health and resilience of coral reef ecosystems are not adversely impacted
- a. Prioritize the protection of coral reef ecosystems in coastal development and land-use and sea-use management in coastal areas, through the application of area-based management measures, such as marine and coastal protected areas and/or marine spatial planning;
  - b. Ensure that consideration of long-term climate related impacts are integrated into coastal development and land-use and sea-use planning
  - c. Manage impacts from large-scale tourism development and its consequent habitat loss and alteration in coral reefs and closely associated ecosystems, and support sustainable tourism by providing socioeconomic incentives and empowering coastal community for eco-tourism operation.
9. Identify and apply measures to **improve the adaptive capacity of coral reef-based socio-ecological systems within the local context**, which will ensure sustainable livelihoods of reef-dependent local communities and provide for viable alternative livelihoods:

<sup>8</sup> In total, 88 of the areas described so far to meet the EBSA criteria by the regional workshops convened by the CBD Secretariat in the following regions address coral reefs: Western South Pacific (13 areas); Wider Caribbean and Western Mid-Atlantic (16 areas); Southern Indian Ocean (24 areas); Eastern Tropical and Temperate Pacific (5 areas); North Pacific (4 areas); South-Eastern Atlantic (11 areas); North-West Atlantic (3 areas); and Mediterranean (12 areas).

- a. Develop and apply socioecological vulnerability monitoring and assessment protocols in coral reef regions, including socioecological vulnerability maps and identify highly vulnerable areas for prioritizing management actions and to inform planning and management as part of a resilience- and ecosystem-based approach;
- b. Prioritize poverty-reduction programmes for reef-dependent communities, to promote livelihood strategies that are socially and ecologically resilient and to reduce poverty-induced overexploitation of reef ecosystems
- c. Develop and implement socioeconomic incentives to encourage coastal communities to play a central role in conservation and sustainable use of coral reefs and closely associated ecosystems, including through, *inter alia*, the use of tax benefits or other economic incentives for sustainable fishing, conservation agreements that rewards users who forego unsustainable activities, and community-based conservation trust funds supported by fees from ecotourism and fines for unsustainable use;
- d. Apply ecosystem-based adaptation (EbA) tools and indicators for use in coral reef regions and incorporate EbA principles and practices into coral reef management;
- e. Incorporate social drivers of coral reef degradation, such as projected human population increase and food security needs, into forecasts of multiple stressor impacts.

10. Establish or further enhance **integrated management and coordination mechanisms** to effectively address multiple stressors to coral reefs, including through the implementation of national coral reef action strategies/plans, as described above:

- a. Integrate ecosystem-based approaches for management and adaptation, into development planning and legislative frameworks at the local, subnational and national level, and identify and remove barriers to implementation;
- b. Apply cross-sectoral, inter-agency area-based management tools, including watershed and marine spatial planning approaches, to effectively reduce local stressors from multiple sources and mitigate their impacts to coral reefs and closely associated ecosystems;
- c. Incorporate watershed-based management approaches into reef management through the application of an integrated land-sea planning approach;
- d. Integrate national coral reef action strategies/plans into existing national mechanisms<sup>9</sup> and broader national priorities such as poverty reduction and sustainable development strategies (including those for population and health, coastal development and food security);
- e. Set in place an inter-agency steering committee at national and/or subnational levels, as appropriate, to coordinate, support and monitor the implementation of national coral reef action strategies/plans;
- f. Empower local communities in reef-management, particularly in remote regions or where capacity is low, by providing necessary resources and capacity-building, and devolution of management responsibilities in line with national/subnational management guidelines.

11. The Executive Secretary of the Convention, in collaboration with existing global (e.g., the International Coral Reef Initiative, ICRI) and regional initiatives, should strengthen international and regional cooperation in support of national implementation of priority actions, as described above,

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<sup>9</sup> National Adaptation Programmes of Action (NAPAs), national biodiversity strategies and action plans (NBSAPs).

through facilitating **information exchange, knowledge sharing, awareness building, capacity-building, sustainable financing, and research and monitoring:**

11.1. Education, awareness and capacity- building

- a. Develop or expand national and regional networks of coral reef managers of all types to promote the exchange of information, knowledge and best practices;
- b. Develop a global coral reef portal linked to the CBD website and existing global and regional initiatives to facilitate technical collaboration and voluntary information sharing on all aspects of sustainable management of coral reefs and related ecosystems;
- c. Facilitate wide implementation of existing training programmes on priority tools and approaches for coral reef management and develop additional training materials in support of implementing priority actions;
- d. Integrate information about coral reefs, environmental conservation and ecosystem-based management into existing curricula at all levels of national education systems;
- e. Develop and implement targeted education and awareness campaigns for diverse stakeholders on how communities and stakeholders can increase coral reef resilience by reducing the direct threats facing coral reefs;
- f. Provide training and other capacity development opportunities in support of community-based management initiatives that increase socioecological resilience at the local or subnational level.

11.2. Sustainable financing

- a. Secure, through national sectoral budget systems (e.g., fisheries, environment, climate change adaptation fund, coastal development, tourism, etc.), the necessary financial resources to implement national coral reef action strategies;
- b. Apply comprehensive and diverse financing schemes for coral reef management, and explore opportunities for innovative financing to support local implementation;
- c. Remove key bottlenecks and improve access to funding through capacity-building and streamlining of funding processes;
- d. Demonstrate and increase awareness of the socioeconomic importance of coral reefs and associated ecosystems to local and national economies.

11.3. Research and monitoring programmes

- a. Research on multiple stressor interactions and effects on coral reefs at the species, population and ecosystem level to identify the most damaging local stressors affecting coral reefs ecosystems at the site-based level;
- b. Research to support a resilience-based approach to coral reef management that is embedded within an integrated ecosystem-based management framework;
- c. Develop and implement early warning systems for major reef health incidents such as bleaching or disease events, tropical storms and flood plumes;
- d. Develop water chemistry monitoring programmes for coastal and inshore waters to determine the natural spatial and temporal variability of ocean carbon chemistry, and detect trends;
- e. Research on the sensitivity of species, habitats and communities within coral reefs to changes in ocean carbon chemistry and whether there is a potential for adaptation to ocean acidification in reef organisms;

- f. Incorporate into the framework of management actions a set of broadly applicable and robust indicators for resilience and stressor assessment, and use these indicators to support regular assessments of management effectiveness;
- g. Further develop ecological and socioeconomic criteria and variables for use in vulnerability assessments in coral reef regions, building on existing work; and
- h. Develop mapping tools that combine data on the current status of coral reefs, management efforts and their effectiveness with predictive modelling of stressor effects to generate future scenarios of reef condition and ecosystem service provision.

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